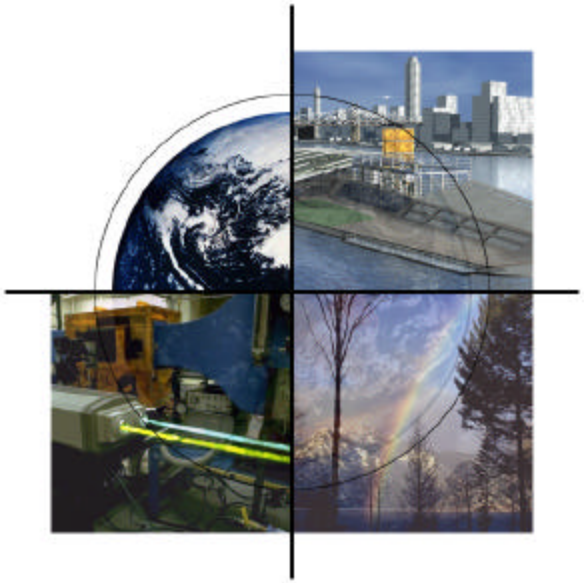
# National Energy Technology Laboratory

## Overview

## and

## Office of Coal and Environmental Programs



**Carl O. Bauer, Associate Director**

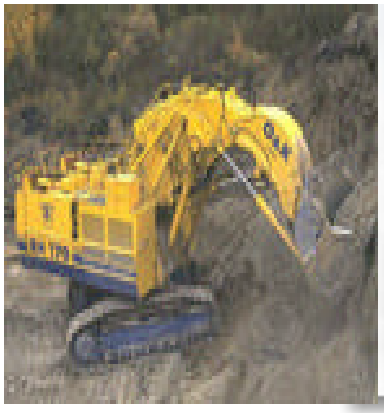
April 2001

# National Energy Technology Laboratory

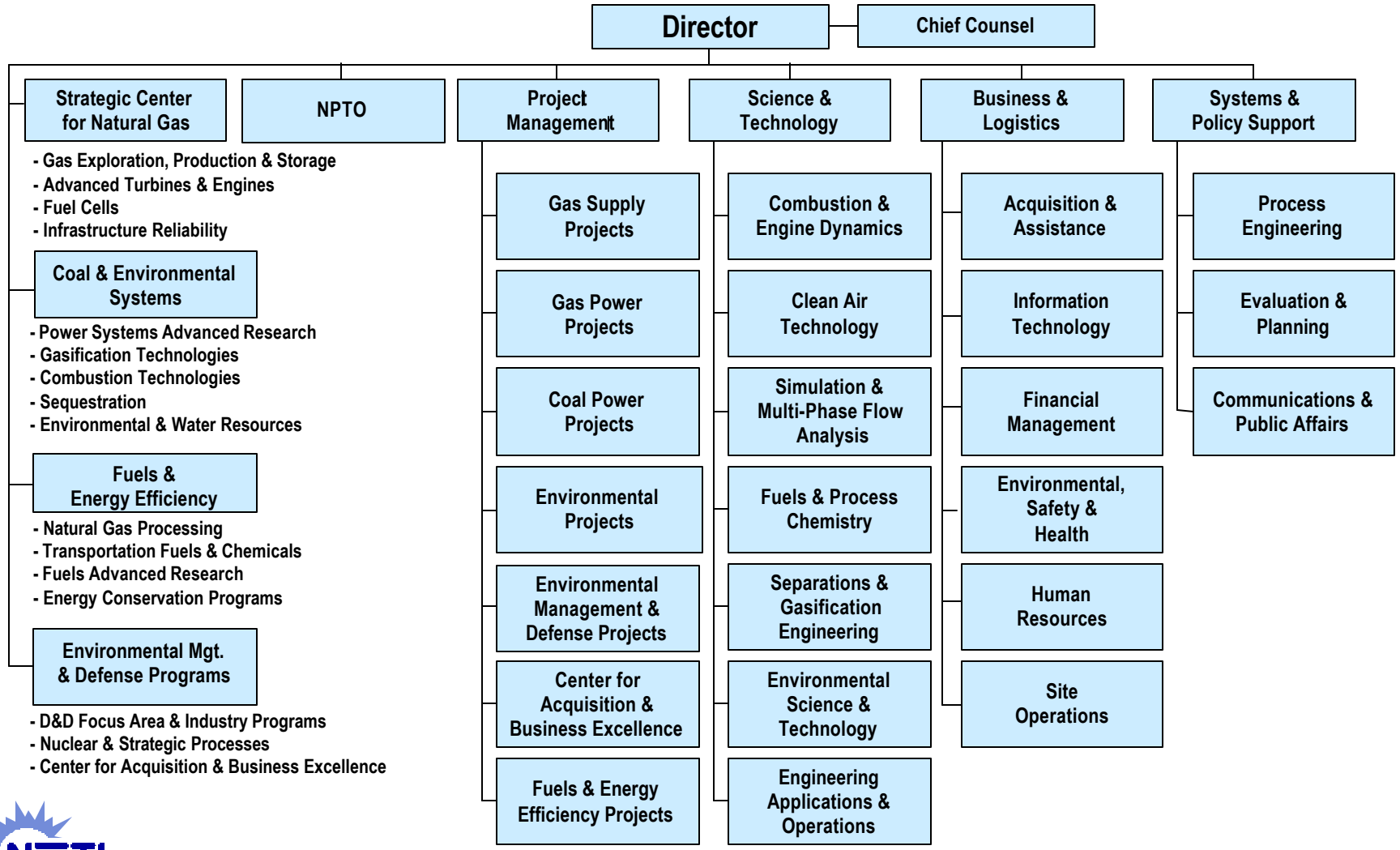
- DOE's Only Fossil Energy National Laboratories
- Extensive extramural R&D with strong industry ties
- Focused on-site science and technology R&D
- Technical support for energy and environmental policy development
- Only Government-owned and -operated National Laboratory

# Our Mission

- **Resolve the environmental, supply, and reliability constraints of producing and using fossil resources to provide Americans with a stronger economy, healthier environment, and more secure future**



# NETL


Director
Chief Counsel
Strategic Center for Natural Gas
NPTO
Project Management
Science & Technology
Business & Logistics
Systems & Policy Support
- Gas Exploration, Production & Storage
- Advanced Turbines & Engines
- Fuel Cells
- Infrastructure Reliability
Coal & Environmental Systems
- Power Systems Advanced Research
- Gasification Technologies
- Combustion Technologies
- Sequestration
- Environmental & Water Resources
Fuels & Energy Efficiency
- Natural Gas Processing
- Transportation Fuels & Chemicals
- Fuels Advanced Research
- Energy Conservation Programs
Environmental Mgt. & Defense Programs
- D&D Focus Area & Industry Programs
- Nuclear & Strategic Processes
- Center for Acquisition & Business Excellence
Gas Supply Projects
Gas Power Projects
Coal Power Projects
Environmental Projects
Environmental Management & Defense Projects
Center for Acquisition & Business Excellence
Fuels & Energy Efficiency Projects
Combustion & Engine Dynamics
Clean Air Technology
Simulation & Multi-Phase Flow Analysis
Fuels & Process Chemistry
Separations & Gasification Engineering
Environmental Science & Technology
Engineering Applications & Operations
Acquisition & Assistance
Information Technology
Financial Management
Environmental, Safety & Health
Human Resources
Site Operations
Process Engineering
Evaluation & Planning
Communications & Public Affairs

# Fossil Energy RD&D Activities Managed as Four Program Areas by NETL

**Electric Power Using Coal**
***Mining to Light Switch***

**Energy Policy Support**
***A Key Issue in Use of Fossil Energy***

**Strategic Center for Natural Gas**
***Borehole to Burner Tip***

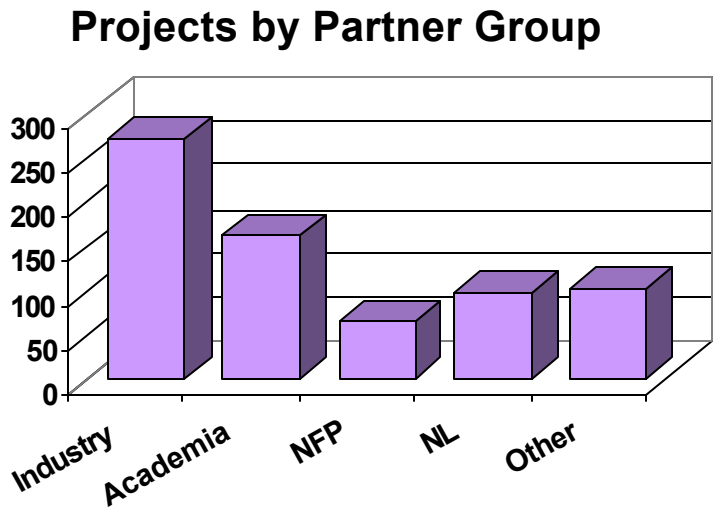
**Clean Fuels**

**Oil Supply NPTO**

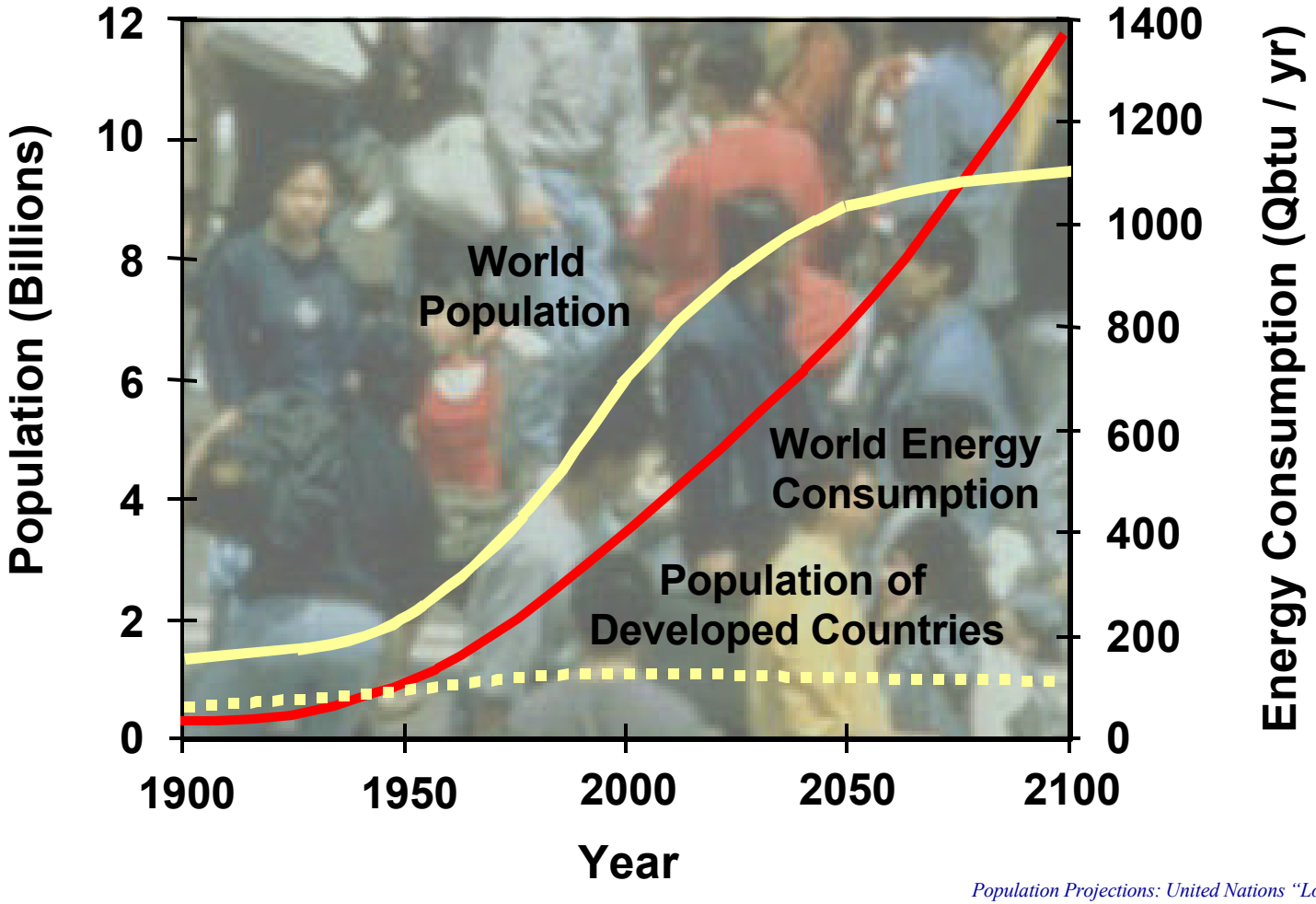
**Fuels from Coal and Gas**
***Supply and Delivery of Clean Fuels for Transportation/ Other End Use Sectors***

# An Extensive Portfolio of Projects with External Organizations

- **Over 800 research activities in all 50 states and 16 countries**
- **Total award value of $7.3 billion**
- **Research performers include:**
  - Private industry
  - Universities/colleges
  - Not-for-profit labs
  - Other DOE national labs
  - Others
- **Private sector cost sharing of $3.9 billion**
  - Leverages DOE funding
  - Ensures relevance
  - Mission accomplishment only through commercialization
- **55 active MOU's and MOA's**



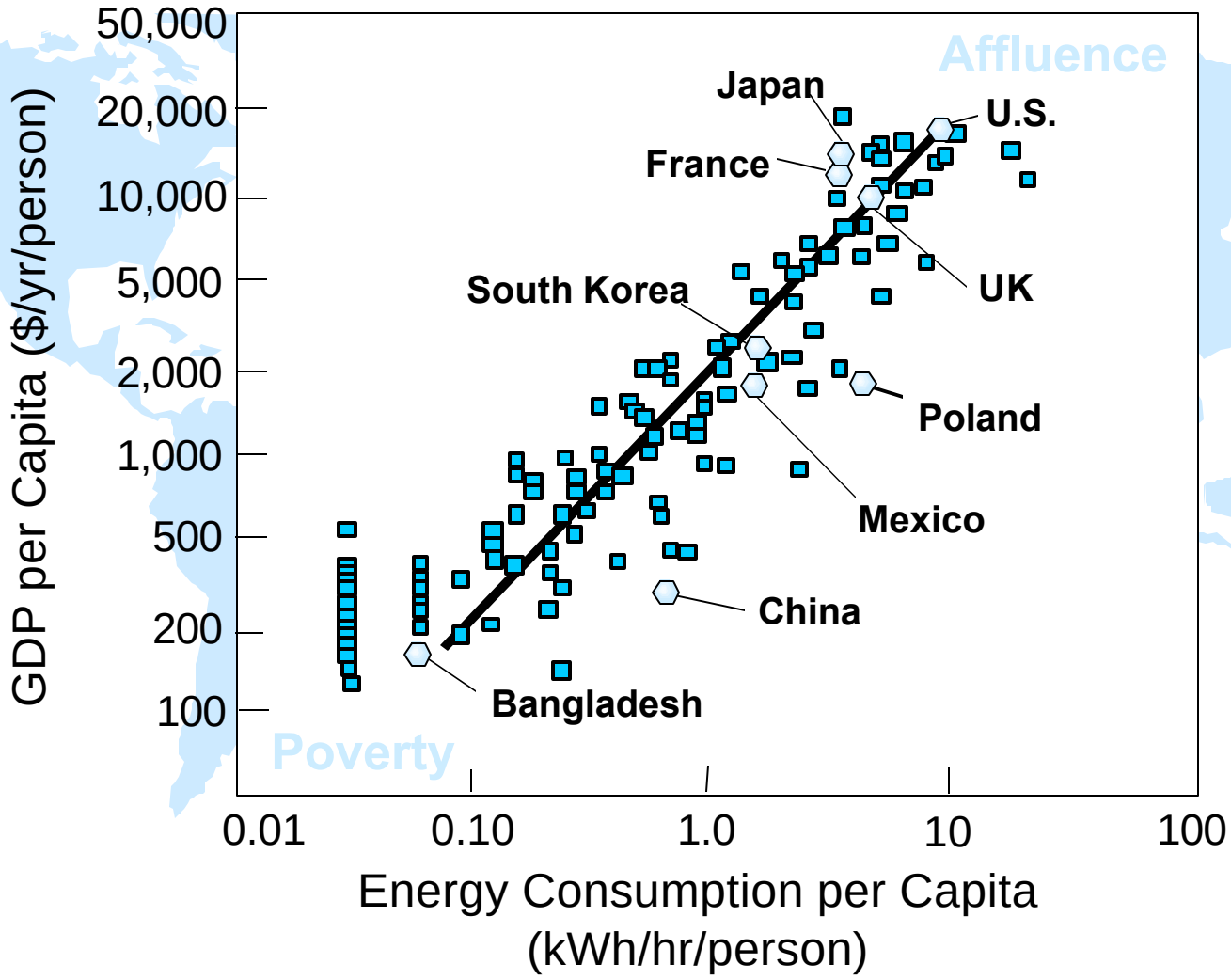
# World Energy Use Is Growing Dramatically




*Population Projections: United Nations "Long-Range World Population Projections: Based on the 1998 Revision"*

*Energy Projections: "Global Energy Perspectives" ITASA / WEC*

# The World Needs Low-Cost Energy



# Replacements for Fossil Energy?

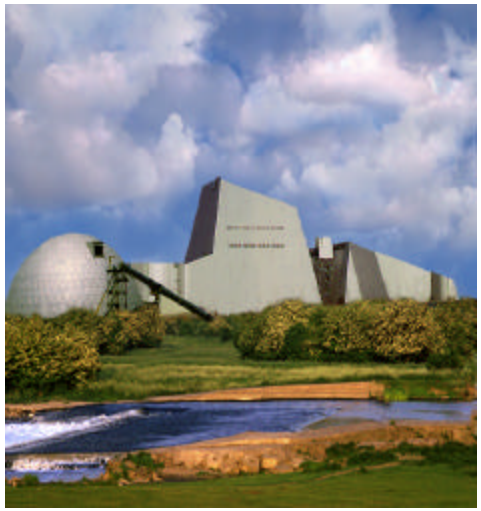
- **Wind/hydro/geothermal**
  - Not enough
- **Biomass**
  - Transportation, land use, expense
- **Solar**
  - Land use, capital cost, storage
- **Nuclear**
  - Expense, politically difficult, proliferation issue
- **Hydrogen**
  - Cost

**Needed: An Affordable, Clean, and Abundant Energy Source**

***No Known Source Meets These Criteria***

# Electric Power Using Coal

*Mining to Light Switch*



## Existing Fleet Technologies

- Emission control (NOx, SOx, PM2.5, mercury/air toxics)
- Efficiency improvements (Clean Coal Demonstrations)

## Mid-Term Markets

- Improved environmental technology
- Efficiency improvements
- Repowering & retrofitting
- Power Plant Improvement Initiative

## Vision 21-Future Energy Plants

- Near-zero emissions
- Technology innovation
- Market flexibility and competitive economics

## Carbon Sequestration: An Important Option to Address Climate Change

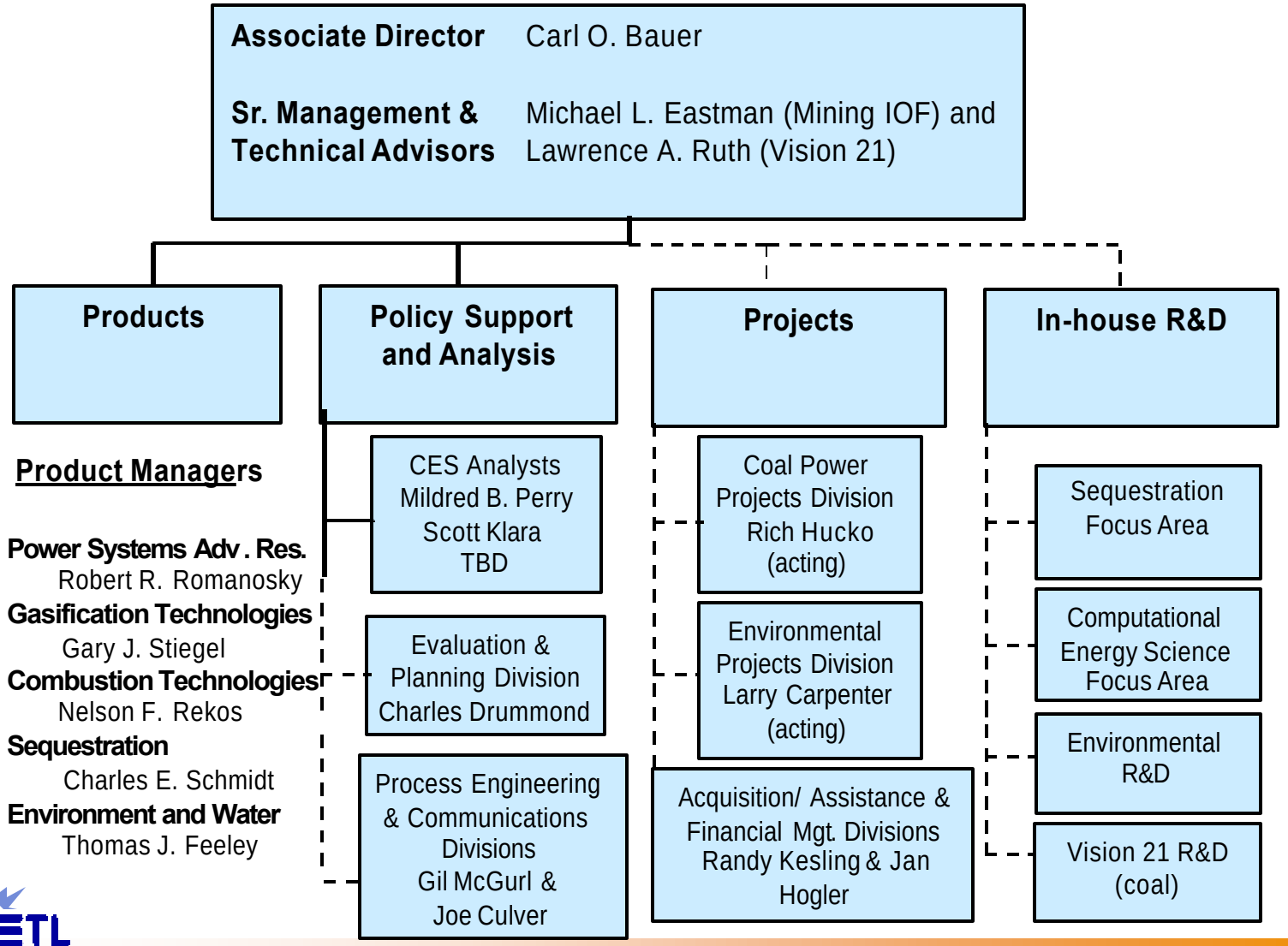
- Low-cost capture
- Long-term storage

## Mining/Water: Addressing Energy Supply Issues

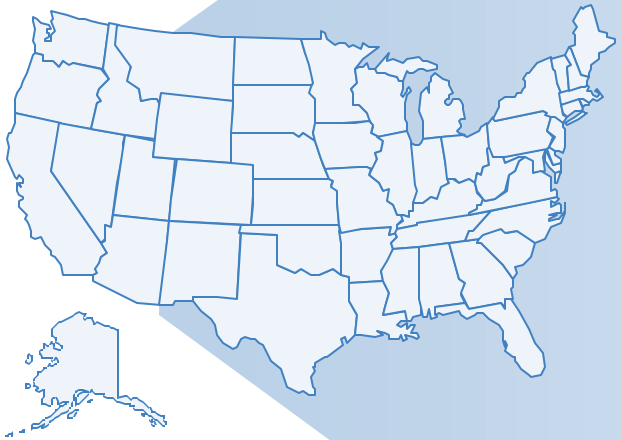
- Mining "Industry of the Future"
- Watershed management

# Coal and Environmental Systems Program

## "A Strategic Center for Coal"

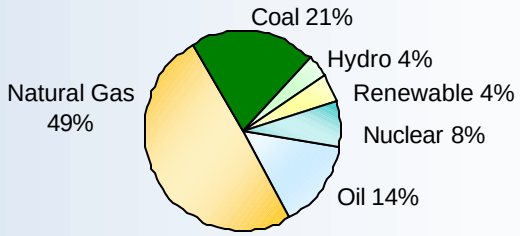


# Coal Meets Much of Our Stationary Energy Needs



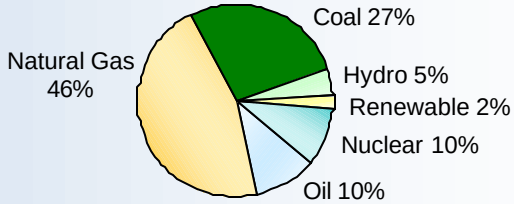
*% From Coal*

***Homes***



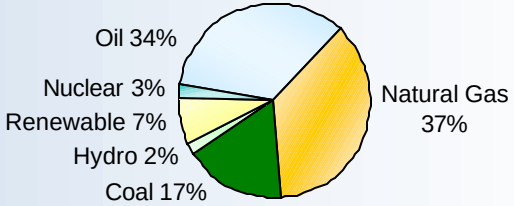

**21%**

***Businesses***



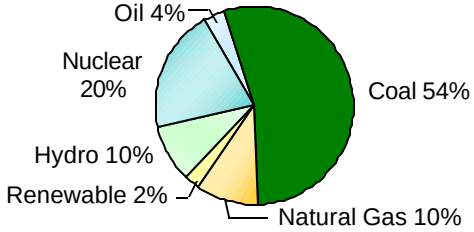

**27%**

***Industry***




**17%**

***Electricity***



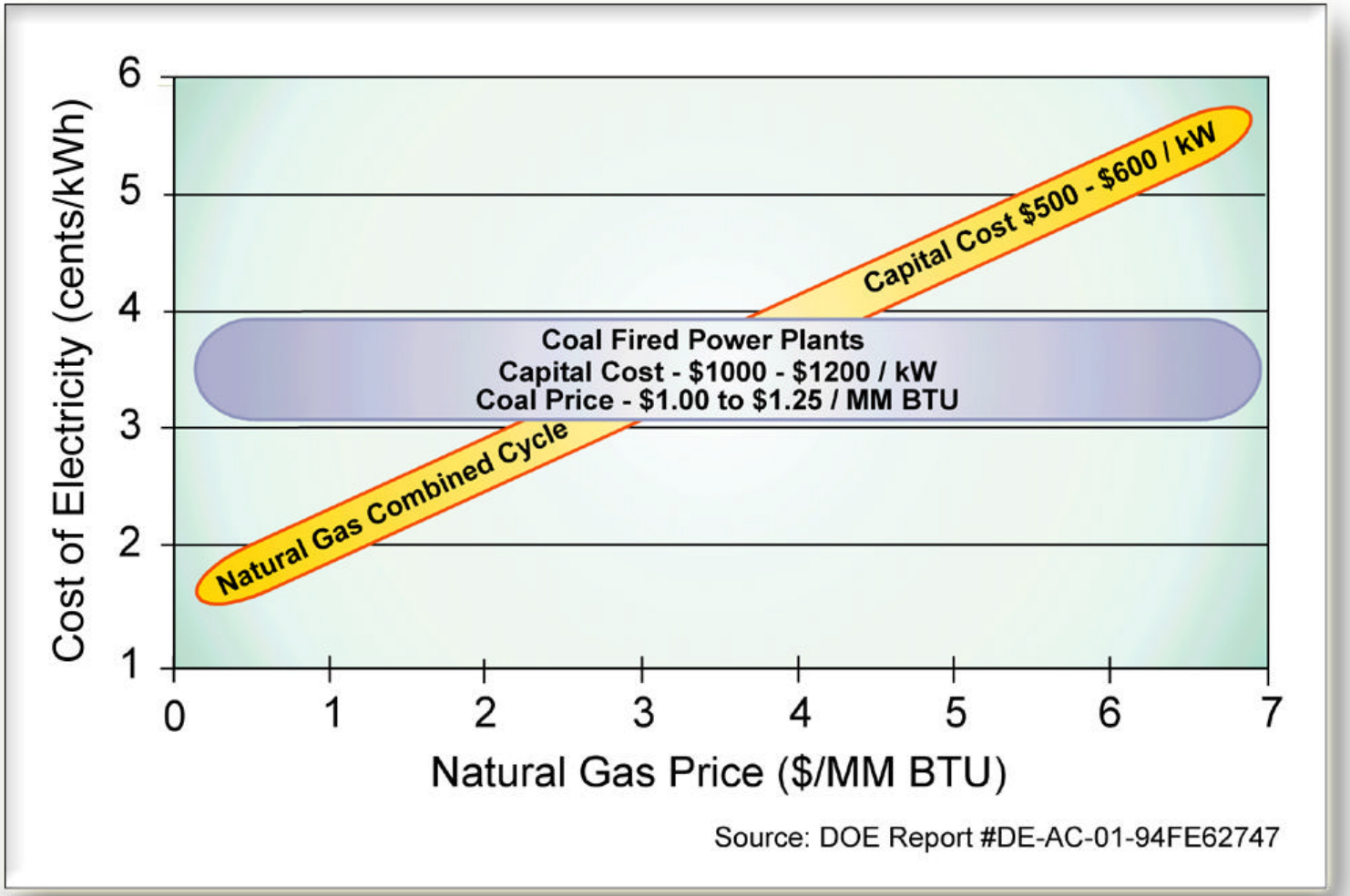

**54%**

*Source: EIA, Annual Energy Outlook, 2001*

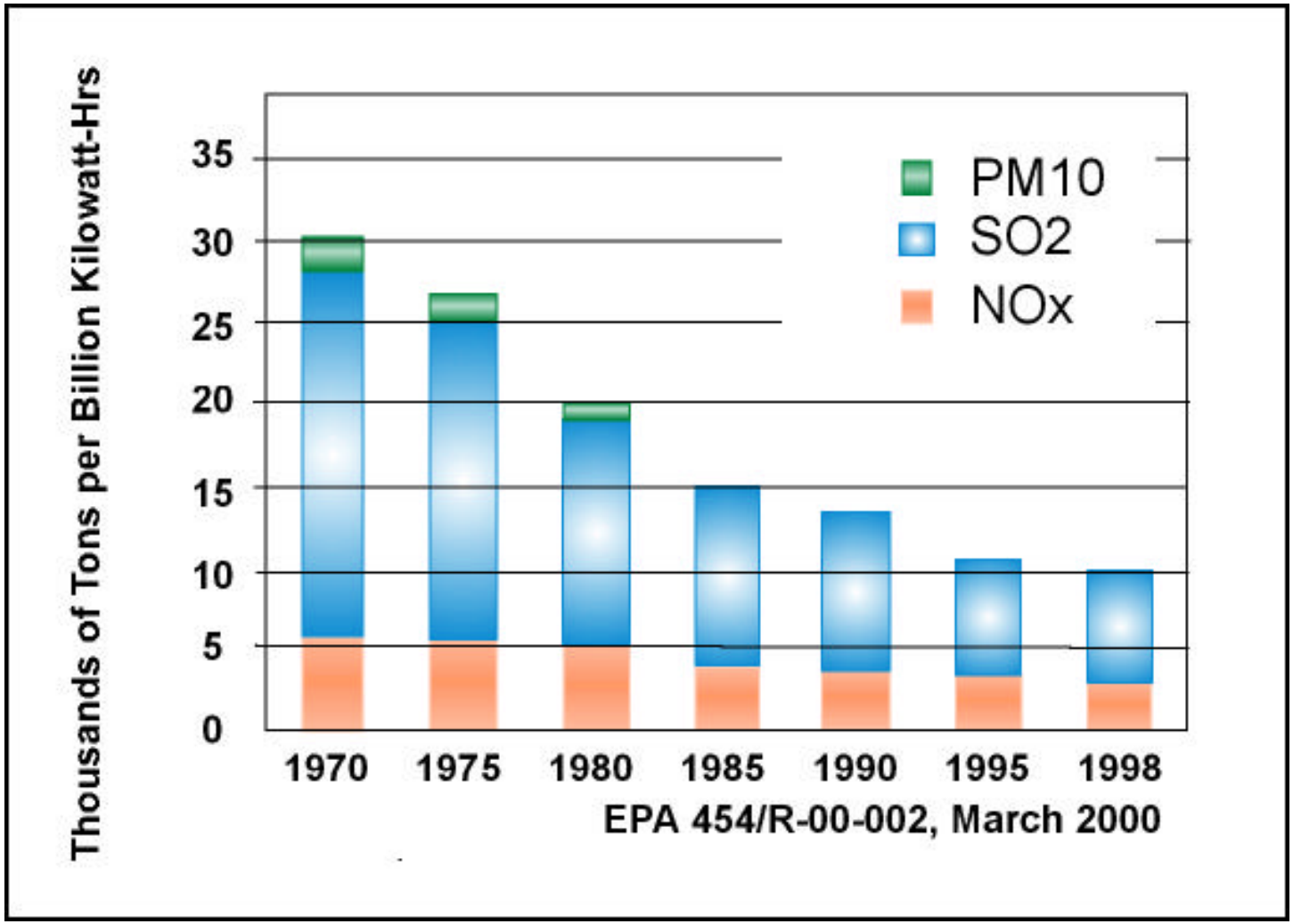
# Benefits Legacy from CCT Program and Associated RD&D

- Life-Cycle Cost Savings to Industry and the Public for Near-Term Deployment
  - Lower capital and operating costs for advanced power plants and NOx and SO2 pollution control systems equate to $23 billion.
  - Lower compliance costs for air toxics and solid waste, through technology development, is estimated at $70 billion.
  - Market value of SO2 and NOx reduction is estimated at $10 billion.
  - Improved waste characterization and advances in waste recovery are estimated to result in a $25 billion cost benefit.

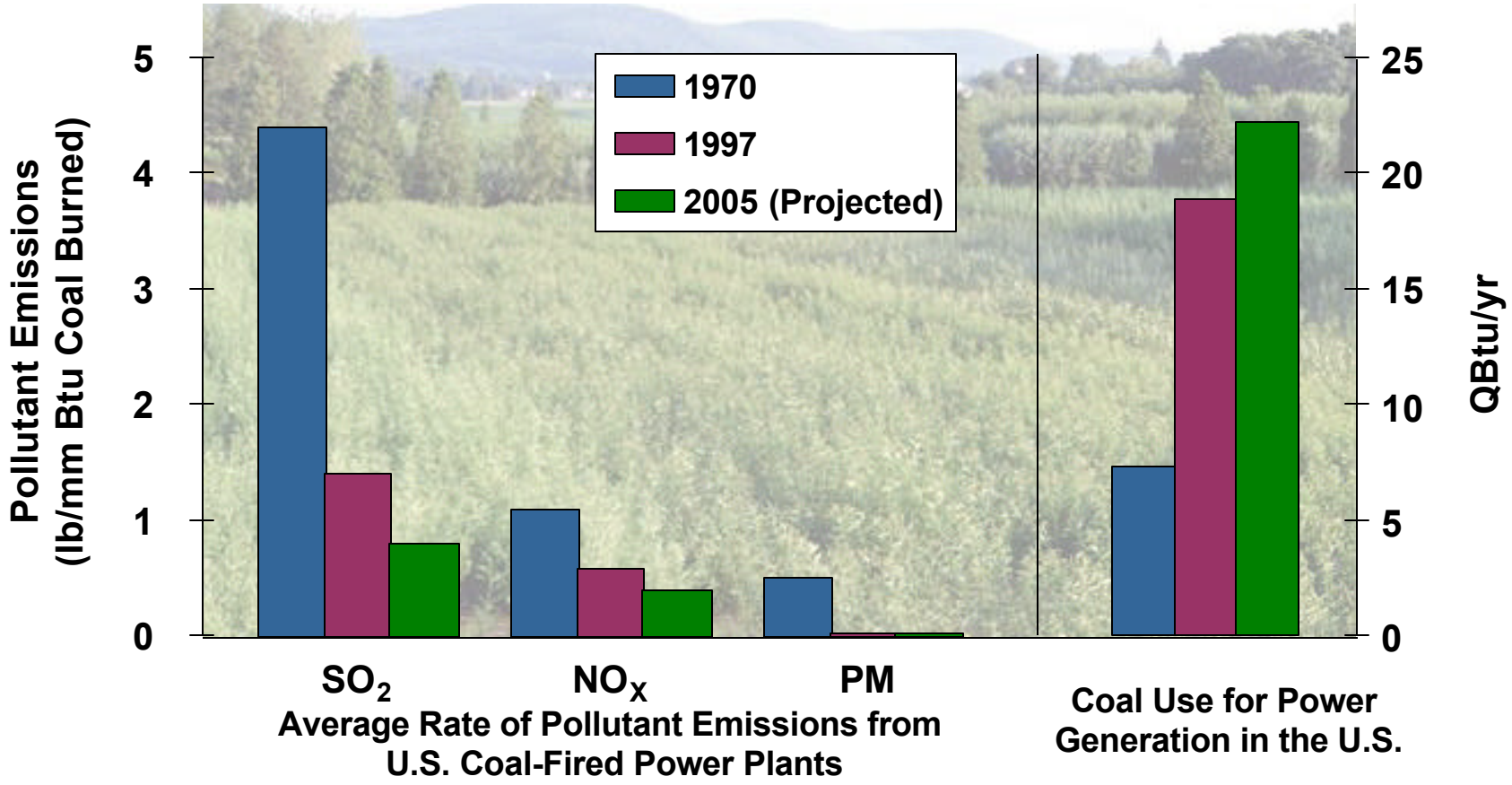
# Coal Technologies Are Cost Competitive



# Coal Technologies Keep Getting Cleaner



# Improved Environmental Performance




**Successes to date:** pollutant emissions per unit of coal burned have decreased significantly

# Comparison of Power Generation Technologies

| | Average (1999) | State-of-the-Art (2000) | | | Future (2010) | | |
|---|---|---|---|---|---|---|---|
| | PC | PC | IGCC | NGCC | PC | IGCC | NGCC |
| Nominal Efficiency HHV % (LHV%) | 33 | 40 | 43 | 52 (57) | 44 | 52 | 58 (63) |
| $SO_2$ Emissions lb/$10^6$ Btu (lb/MWh) | 1.3 (13.8) | 0.05 (0.5) | 0.02 (0.15) | ~ 0 | 0.025 (0.2) | 0.017 (0.13) | ~ 0 |
| $NO_x$ Emissions lb/$10^6$ Btu (lb/MWh) | 0.5 (5.2) | 0.15 (1.3) | 0.04 (0.31) | 0.028 (0.20) | 0.03 (0.3) | 0.024 (0.18) | 0.028 (0.20) |
| Particulate Emissions lb/$10^6$ Btu (lb/MWh) | 0.05 (0.5) | 0.01 (0.08) | 0.007 (0.053) | ~ 0 | 0.01 (0.08) | 0.002 (0.015) | ~ 0 |
| Fuel Type Cost - \$/$10^6$ Btu | Coal 1.2 | Coal 1.2 | Coal 1.2 | Gas 3.5 - 7.5 | Coal 1.1 | Coal 1.1 | Gas 4.0-7.0 |
| Capital Cost 1999 \$/kW | N/A | 1000 | 1200 | 550 | 950 | 1000 | 500 |
| Cost of Electricity 1999 ¢/kWh | 4.0 | 3.5 | 3.7 | 4.0 - 6.8 | 3.4 | 3.1 | 3.5-6.0 |

# Basis / Assumptions for Technology Comparisons

| | Average (1999) | State-of-the-Art (2000) | | | Future (2010) | | |
|---|---|---|---|---|---|---|---|
| | PC | PC | IGCC | NGCC | PC | IGCC | NGCC |
| Technology | Sub Critical | Super Critical | Texaco $O_2$ Blown | "H" Frame | Ultra Super Critical | Advances in Sub Components | Next Generation Turbine |
| $SO_2$ Control Technology | Low Sulfur Coal and/or FGD | Wet Limestone 96% - 98% | Amine & Claus or Hot Gas Clean-Up | Sulfur free natural gas | Wet Limestone > 99% | Hot Gas Clean-Up | Sulfur free natural gas |
| $NO_x$ Control Technology | Combustion Mods such as Low $NO_x$ Burners | Low $NO_x$ Burner, and SNCR or SCR | Quench & Staged Combustion | Combustion Mods such as zoning / staging | Low $NO_x$ Burner, and SCR | Quench & Staged Combustion | Combustion Mods, such as zoning / staging |
| Particulate Control Technology | Baghouse or ESP | Baghouse or ESP | Ceramic Candle Filter | Particulate free Natural gas | Baghouse or ESP | Ceramic Candle Filter | Particulate free Natural gas |
| Size (MW) | 350 | 400 | 350 | 400 | 400 | 500 | 400 |

**Notes:** Assumes levelized costs
20 year book life
Nominal 70% plant capacity factor
Current maximum NSPS limits applicable to these plants
- $SO_2$ – 1.2 lbs/$10^6$ Btu and 90% reduction or 0.6 lbs/$10^6$ Btu and 70% reduction
- $NO_x$ – 1.6 lbs/$10^6$ Btu for new construction
- PM – 0.03 lbs/$10^6$ Btu

**Nomenclature:** PC = Pulverized Coal
IGCC = Integrated Gasification Combined Cycle
NGCC = Natural Gas Combined Cycle

**References:** DOE Report #DE-AC01-94FE62747
EIA Annual Energy Outlook 2001
DOE NETL Program Goals / Extrapolations
Discussions with equipment vendors and contractors

# Electric Power from New Plants Using Coal

## (~15 GW New Capacity Proposed at $18 Billion Investment)

| SPONSER | PROPOSED LOCATION | SIZE | TIMING | INVESTMENT | COAL TYPE |
|---|---|---|---|---|---|
| Tuscon Electric Power | Springerville Arizona | 2 Units 380 MW each | Initiate - 2001 In Service - 2004, 2005 | ~ $ 500 Million | Sub-Bituminous |
| Tri-State Generation and Transmission | Las Animas Colorado | 500 to 600 MW | Initiate - 2001 In Service - TBD | $ 1.2 Billion | TBD |
| Corn Belt Energy (DOE) | Elkhart Illinois | 91 MW | Initiate - 2001 In Service - 2004 | $ 137 Million | Waste Coal |
| Southern Illinois Power | Marion Illinois | 120 MW | Initiate - 2000 In Service - 2002 | $ 50 Million | Bituminuous Coal Fines |
| EnviroPower | Sullivan County Indiania | 500 MW | Initiate - 2001 In Service - 2004 | $ 600 Million | Waste Coal |
| EnviroPower | Pike County Indiania | 500 MW | Initiate - 2001 In Service - 2004 | $ 600 Million | Waste Coal |
| EnviroPower | Knott County Kentucky | 525 MW | Initiate - 2001 In Service - 2005 | $ 600 Million | Waste Coal |
| East Kentucky | Maysville Kentucky | 250 MW | Initiate - 2001 In Service - TBD | ~ $ 300 Million | TBD |
| Global Energy (DOE) | Clark County Kentucky | 400 MW | Initiate - 1999 In Service - TBD | $ 432 Million | High Sulfur KY Bituminous |
| Peabody Group | Central City Kentucky | 1500 to 2000 MW | Initiate - TBD In Service - TBD | TBD ~ $3 Billion | Western Kentucky high-sulfur coal |
| AES Corporation | Cumberland Maryland | 180 MW | Initiate - 1996 In Service - 2001 | ~ $ 200 Million | Maryland Coal |
| Tractebel Power | Choctaw County Mississippi | 440 MW | Initiate - 1997 In Service - 2001 | ~ $ 400 Million | Lignite |

# Electric Power from New Plants Using Coal

## (~15 GW New Capacity Proposed at $18 Billion Investment)

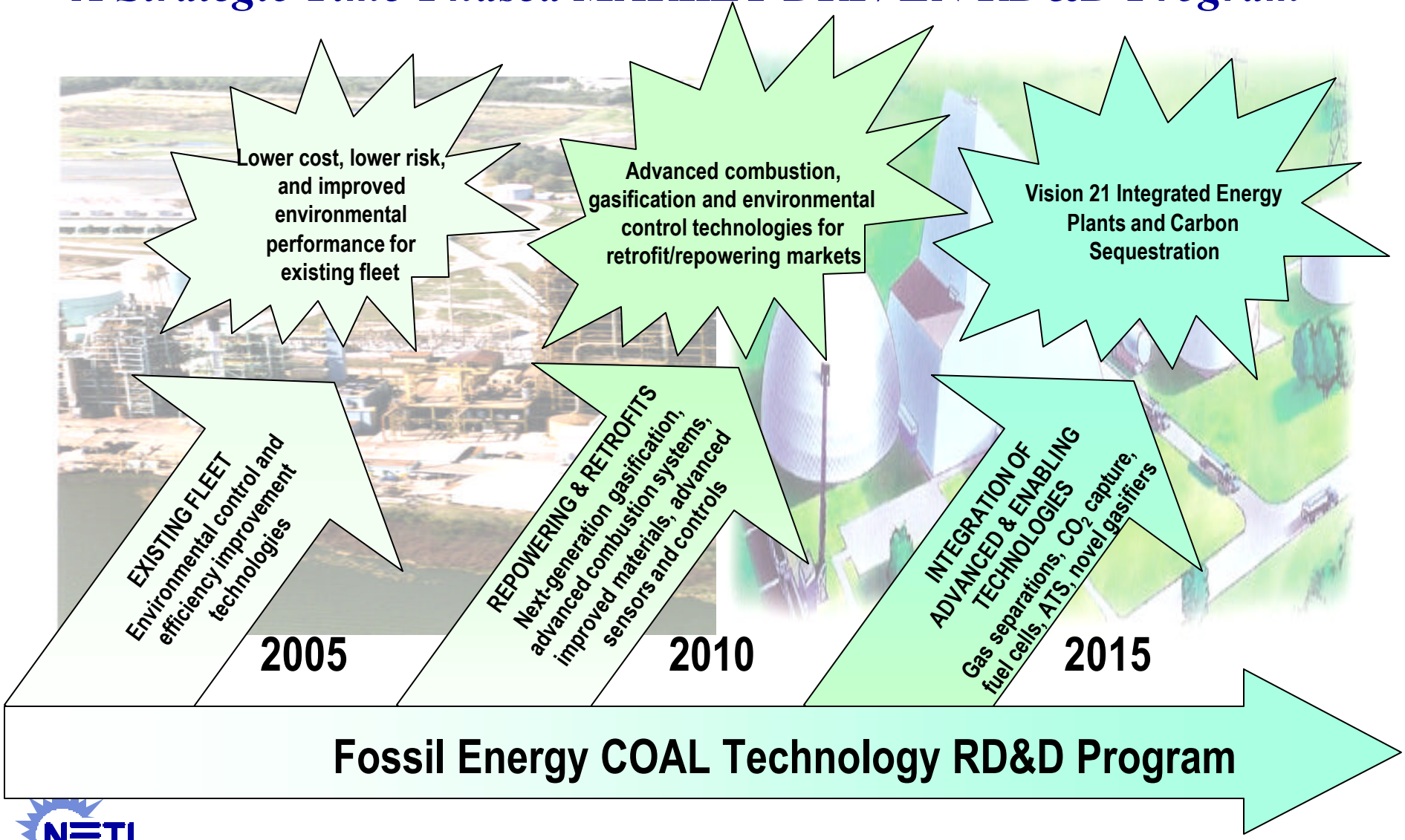
| SPONSER | PROPOSED LOCATION | SIZE | TIMING | INVESTMENT | COAL TYPE |
|---|---|---|---|---|---|
| LS Power Services | Osceola<br>Mississippi | 1200 to 1600 MW | Initiate - 2001<br>In Service - 2005 | $ 1 Billion | TBD |
| Composite Power | Bear Creek<br>Montana | 4 Plants<br>500 MW each | Initiate - 2001<br>In Service - 2006 | $ 1.5 Billion | Montana<br>Coal Deposits |
| Great River Energy or Westmoreland Coal or Montana Dakota Utility | North Dakota | 500 MW | Initiate - 2001<br>In Service - 2008 | $ 800 Million | North Dakota<br>Lignite |
| Reliant Energy | Indiana<br>Pennsylvania | 520 MW | Initiate - 2001<br>In Service - 2004 | $ 800 Million | Waste Coal |
| U.S. Electric Power | Whatcom County<br>Washington | 249 MW | Initiate - 2001<br>In Service - 2004 | ~ $ 300 Million | Low Sulfur Coal<br>Vancouver |
| Wisconsin Energy & Madison Gas | Oak Creek<br>Wisconsin | 3 Plants<br>600 MW each | Initiate - 2002<br>In Service - 2007, 2009, 2011 | $ 2.5 Billion | Powder River Basin<br>Sub-Bituminous |
| Alliant Energy | Wisconsin | 500 MW | Initiate - 2001<br>In Service - 2006 | ~ $ 600 Million | TBD |
| Black Hills Corp. | Gillette<br>Wyoming | 80 MW | Initiate - 1998<br>In Service - 2003 | $ 100 Million | Powder River Basin<br>Sub-Bituminous |
| Black Hills Corp. | Gillette<br>Wyoming | 500 MW | Initiate - 2001<br>In Service - 2005 | ~ $ 600 Million | Powder River Basin<br>Sub-Bituminous |
| Intermountain Power | Southwest<br>Utah | 500 to 800 MW | Initiate - TBD<br>In Service - 2006 | $ 800 Million | West Ridge Mine |
| Utah Governor<br>Mike Leavitt (R) | Delta<br>Utah | 3 Plants<br>500 MW each | Initiate - TBD<br>In Service - TBD | TBD<br>~ 2.5 Billion | TBD |
| | | | | | |
| | | | | | |

# Coal-Based Power Production
# Issues and Opportunities

- **Electric power reliability**
  - Multi-pollutant control
  - Fine particulates ($PM_{2.5}$) and Hg
  - Improved efficiency
  - Global climate change

# Coal-Based Power Technologies

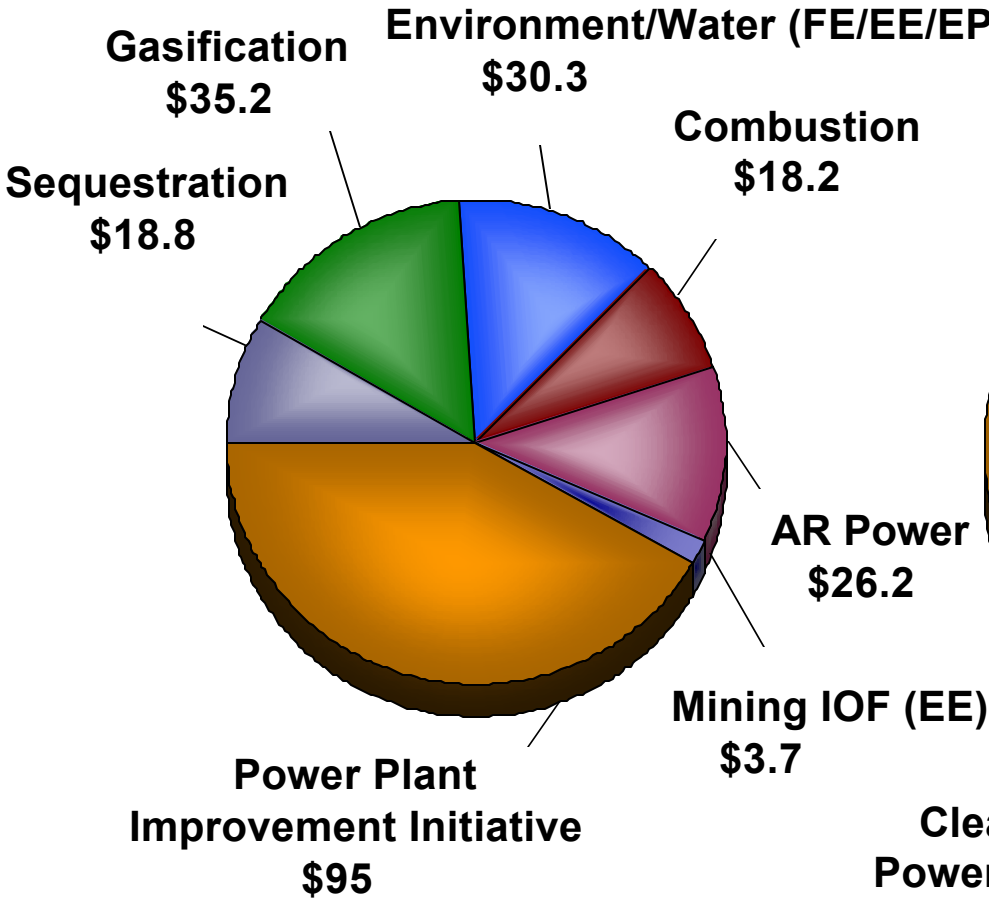
## *A Strategic Time-Phased MARKET DRIVEN RD&D Program*



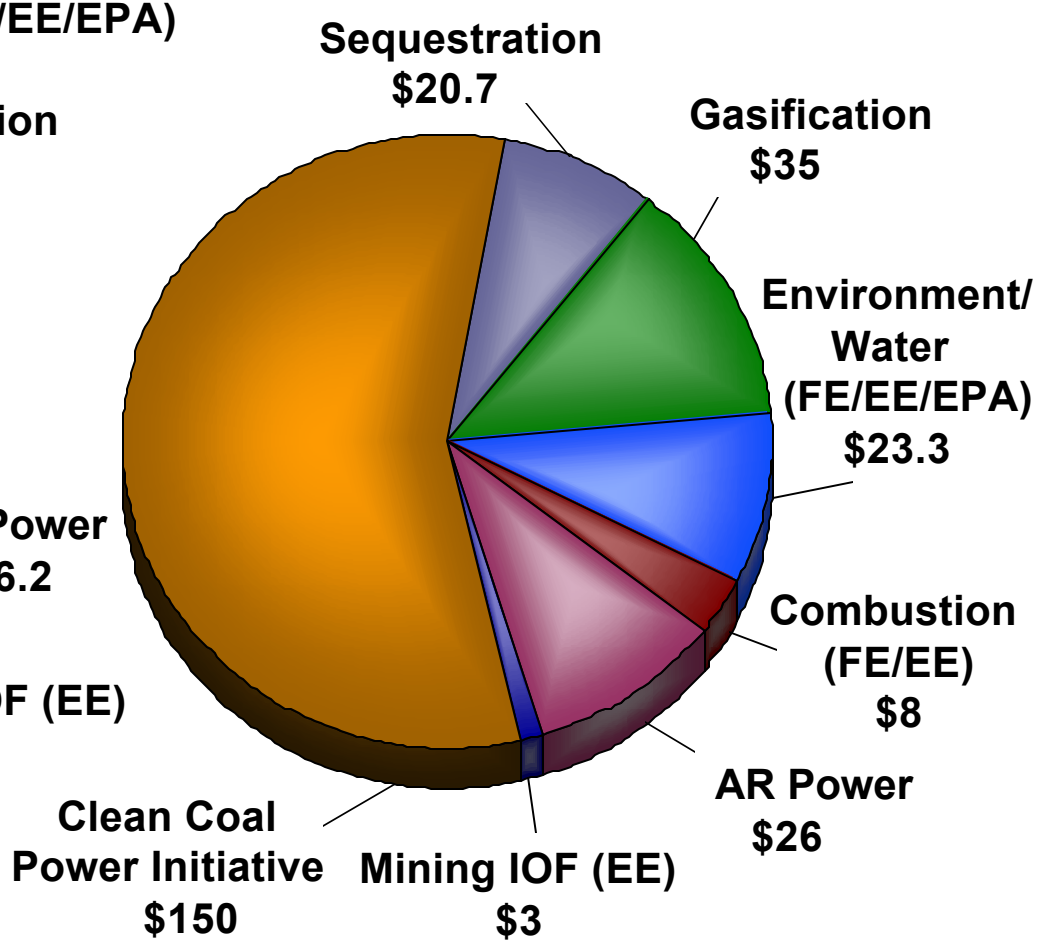
# Coal and Environmental Systems*
# FY 2001/FY 2002 Budget Comparisons

(all sponsors)

**FY 2001 $227.4M**

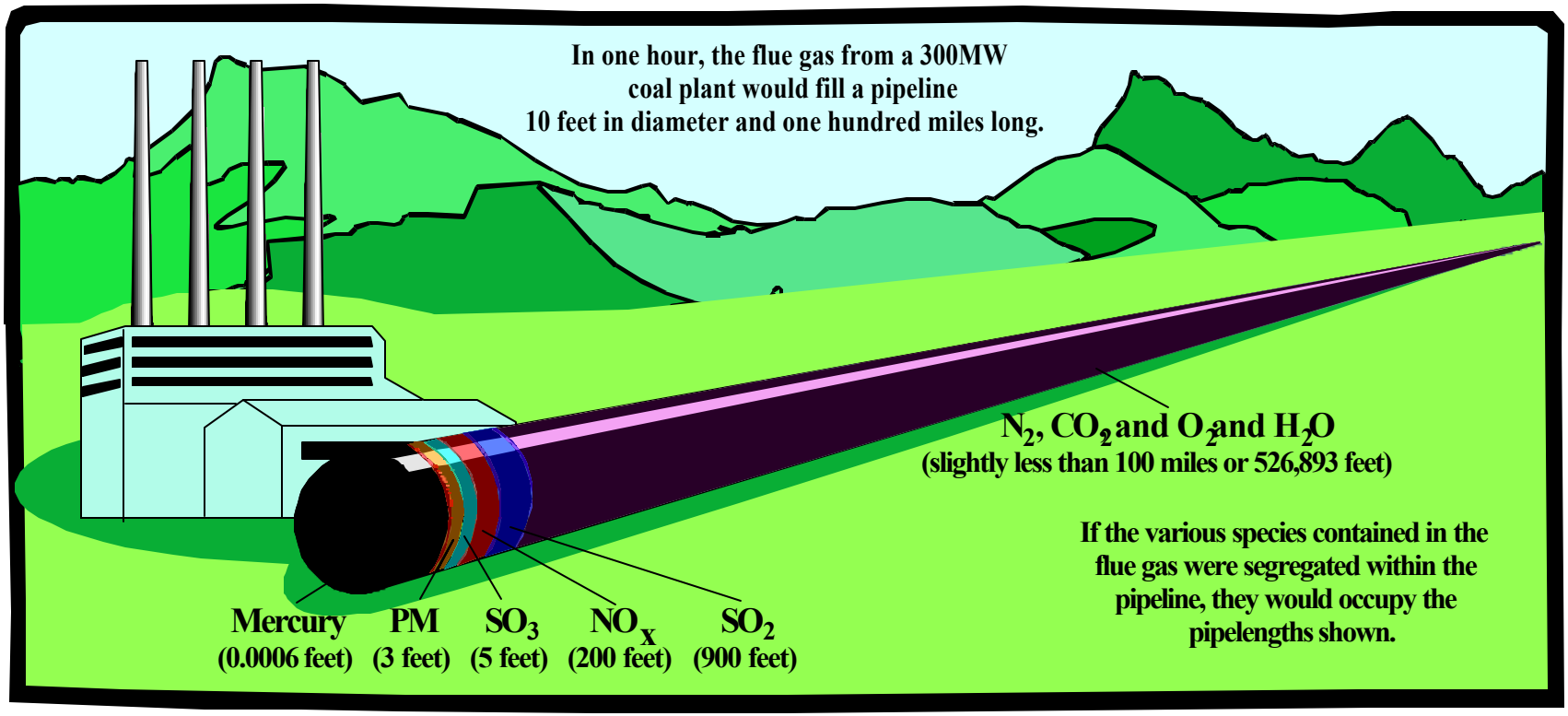



**FY 2002 $273M** (DOE request)




*excluding CCT

# Traditional Pollutants



# Vision 21

## *Ultra-Clean Energy Plant of the Future*

### *Energy Plants for Post-2015*

- **Use available feeds:**
  - Coal, gas, biomass, waste
- **Electricity is a primary product**
  - Can co-produce fuels, chemicals, steam, heat

### *Goal:*

**Absolutely Minimize Environmental Implications of Fossil Energy Use!**

### *Approach:*

- **Maximize efficiency**
  - 60% coal-to-electric
- **Near-zero emissions**
  - Option for carbon sequestration

# Vision 21 Program Objectives

## Capital & Operating Costs/RAM

- Vision 21 must be competitive with other energy systems with comparable environmental performance

## Emissions

- < 0.01 lb/$10^6$ Btu $SO_2$ and $NO_x$
- < 0.005 lb/$10^6$ Btu PM
- <1/2 organic compounds in *Utility HAPS Report*
- <1 lb/$10^9$ Btu Hg

## Schedule of Benefits

- Technology spinoffs by 2005
- Designs for modules by 2012
- Commercial plant designs by 2015

## Efficiency

- Electricity generation
  - coal based 60% (HHV)
  - gas based 75% (LHV)
- Fuels only plants 75% (LHV)

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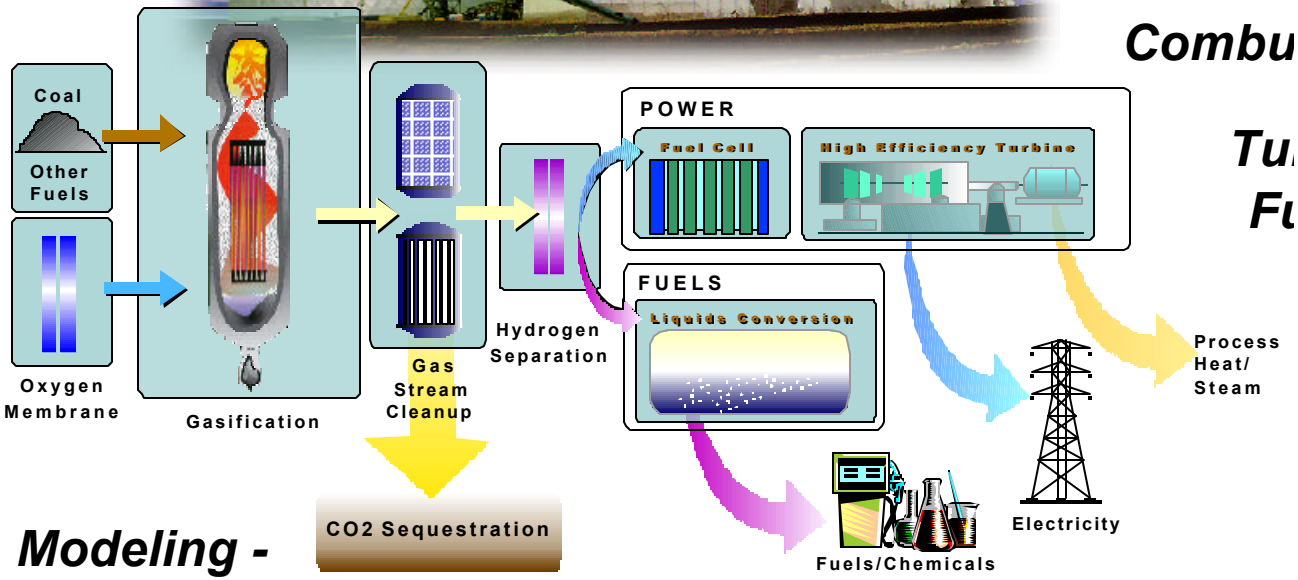


**Modeling -**

# Advanced Technologies Will Play a Crucial Role in Addressing Climate Change